Dialectical Materialism and Modern Science

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I. EVERYTHING HAS A HISTORY

In this series of articles I propose to examine the question of how far the scientific discoveries of the generation which has elapsed since Lenin wrote *Materialism and Empirio-criticism* have verified the principles of dialectical materialism. These principles were formulated by Marx, and in much greater detail by Engels, and developed by Lenin and Stalin. " Nature," wrote Engels,[1] " is the test of dialectics," and dialectical materialism can only be accepted if it proves a guide not merely to an understanding of the development of science, but also to actual scientific research.

Its opponents say that it is a dogma to which scientific publications in the Soviet Union must conform, as scientific publications in mediæval Europe had to conform to the current theology. But dialectical materialism does not state the nature of matter. " For the sole property of matter," wrote Lenin,[2] " with the recognition of which materialism is vitally concerned, is the property of being objective reality, of existing outside of our cognition." It states that matter is in a constant state of flux, that development occurs through a struggle of opposites, and so on, but it does not lay down where in nature such struggles are to be found. It merely prompts us to look for them, and helps us to understand them when discovered.

A certain number of scientists today are idealists, partly because our knowledge of cerebral physiology does not yet permit of a detailed theory of mind, but largely because it is abundantly clear that matter does not have the properties which were ascribed to it a generation ago by the majority of scientists, though not, of course, by dialectical materialists. Hence the idealists conclude that matter does not exist. This conclusion is, of course, very welcome in reactionary circles. If matter is defined as consisting of indestructible atoms it certainly does not exist. But thirty-three years ago Lenin wrote: " The recognition of immutable elements, of the immutable substance of things, is not materialism, but is metaphysical, anti-dialectical materialism." We shall see what has happened to the supposedly immutable atoms of nineteenth-century science.

After Mendeleyev had formulated the periodic law, chemists gradually discovered new elements until today all but one of the ninety-two elements between and including hydrogen, the lightest, and uranium, the heaviest, are known, and one or two heavier than uranium are suspected. Aston found that these elements are mixtures of atoms of slightly different weights. In fact there are not ninety-two, but several hundred kinds of stable (or more accurately nearly stable) atom, each atom consisting of a heavy nucleus round which from one to ninety-two much lighter electrons revolve.

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[1] *Anti-Dühring.* [2] *Materialism and Empirio-criticism.*

Rutherford showed that some naturally occurring atomic nuclei are unstable, and break down to yield lighter types of atom. But till recently these could be regarded as exceptions. In the last ten years, however, most of the elements have been bombarded with particles of high velocity, produced either by naturally radio-active substances or by the very intense electric fields, ranging to millions of volts, which modern developments of electrical industry have made possible. Such bombardments produce new types of unstable atomic nucleus. These are being discovered at such a rate that already probably more different kinds of unstable than of stable atom are known. The atoms of ordinary chemistry are only the survivors of a much greater number of less stable types, and even the stablest of them can be altered, and are constantly being altered, by cosmic radiation and other agents, though extremely slowly on our earth. But such processes must be relatively rapid in the interior of the sun and other stars, and act as the main source of their light and heat.

An atomic nucleus may be considered as built up of lighter particles such as protons, neutrons, and electrons. These particles can be studied, and their properties determined; and physicists naturally tended to regard them as " immutable elements " once the atom had proved not to be immutable. But they soon proved not to be immutable either. For example, there are electrons of positive as well as negative electric charge. They do not last long, for when a positive and negative electron collide, they pass over into a flash of high frequency radiation. And under certain circumstances radiation may generate a pair of electrons of opposite charges. " Contrary to metaphysics," wrote Stalin,[1] " dialectics holds that nature is not a state of rest and immobility, stagnation and immutability, but a state of continuous movement and change, of continuous renewal and development, where something is always arising and developing, and something always disintegrating and dying away." This view is completely borne out by modern physics, provided we realize that there is an immense range of different stabilities. The most transitory known objects, such as the particle called the meson, have an expectation of life of less than a millionth of a second. The stablest, such as the nuclei of ordinary atoms under terrestrial, though not solar, conditions, have an expectation of many thousand million years.

It may be answered that at least the laws of nature are stable, and that here at any rate immutability can be found. If so it is fairly clear that the universe is " running down," as Clausius believed, towards a condition of " heat death " in which the heat is evenly distributed, and that it cannot have existed for ever in the past. Thus a creation, or at any rate some breach of natural law in the past, must be postulated; and we are back at essentially the Newtonian theology, where the creator established eternal laws and leaves the universe to work out its own destiny. This fits in very well with the ideology of a bourgeoisie which realizes that there was a pre-capitalist period, but believes that the laws of capitalist economics are eternal.

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[1] *History of the C.P.S.U.* (*B*)

Engels did not completely escape from this difficulty. He saw that thermodynamics, as formulated in his day, was self-contradictory, for the laws then given could not have held for ever. So he speculated concerning a building up of the lost heat of the stars into motion somewhere in the depths of space, which would allow the origin of new solar systems when our own has become cold. Thus eternity would be filled by cycles of more or less similar events, and the universe as a whole would have no history, being of the same general character as at present a million million years in the future or the past.

But some modern mathematical physicists, notably Lemaitre, Dirac, and Milne, take a different view, according to which laws of nature change, and the general character of the universe therefore alters, though, of course, very slowly. Milne's cosmology is the most fully developed of these, and the most dialectical. Our sun is one star out of perhaps a million million in a system whose densest parts we see as the Milky Way. We shall deal with the development of stars in a later article. Hundreds of thousands of other galaxies are known. The more distant they are the redder their light. This may be interpreted as due to their moving away, or to the speeding up of atomic events, so that light which started a hundred million years ago is of lower frequency, and therefore redder, than light which starts from similar atoms to-day. Each interpretation demands a different time scale and a different geometry. On the scattering or " expanding universe " interpretation light frequencies and rates of chemical change are constant. But everything, including material objects, is expanding by about one two-thousand millionth part per year; and two thousand million years ago all matter was packed into an indefinitely small volume, and ordinary physical events, such as the rotation of the earth, took place in an indefinitely short time. On the other interpretation there is no expansion, and no slowing down of physical events. However geometry is not Euclidean. The two interpretations are not different theories of the universe, but different systems of measurement. For they lead to just the same predictions, though stated in different words, and there is no way of deciding between them. The latter is by far the more natural, as it takes ordinary standards, such as the metre and the year, as constant, or very nearly so.

On this interpretation the past and the future are infinite, but in the remote past, say fifteen hundred million years ago, chemical processes were so slow relative to physical that life as we know it was impossible, and the sun and other stars probably produced less heat than today, while in the remote future chemical processes will be so relatively speeded up as to render life still possible even if there is a marked fall in temperature. Milne points out that this development, this qualitative change in the nature of things, is due to the contradictions between the time scale on which radiation proceeds evenly, and that on which the movement of masses is an even process. No doubt this is not a final account of the matter. Milne's theory accords with Einstein's special theory of relativity, but not with his later general theory, some features of which have been verified by observation. Probably later workers will be able to combine the useful features of both

Milne's and Einstein's theories. It is of great interest to find that a natural philosopher who is probably almost uninfluenced by Marxism should ascribe the qualitative development of the universe to the struggle between the wave-like and particle-like characteristics which are present in all matter. To this unity of opposites we shall turn in the next article.

II. THE UNITY OF OPPOSITES

In the physical theories of the nineteenth century the constituents of the world were rather sharply divided into two groups. On the one hand were particles such as chemical atoms, on the other the field between them, or ether, which was the carrier of waves of radiation, including light, radiant heat, and radio waves. The term " matter " was often reserved for the particles, even after it had been found that radiation has mass.

In the twentieth century this distinction broke down. It was found that under certain circumstances radiation, including light and X-rays, was not absorbed continuously, but in definite units, or quanta. The amount of energy in a quantum is quite independent of the intensity of the radiation, but proportional to its frequency. Thus light behaves both as if it were composed of waves, and also as if it were composed of particles, the particles containing more energy in blue than in red light, and far more still in X-rays. The analogy to matter became still stronger when light was found to have weight as well as mass. That is to say it does not merely push an object which absorbs or reflects it, but is bent out of its path by a heavy body, as the French revolutionary Marat had believed, on quite erroneous grounds. The deflection predicted by Einstein and found by Eddington was much smaller than what Marat believed he had discovered.

Still more startling was the discovery that ordinary matter and electrons have wave-like properties. These are already of practical importance in connection with the electron microscope. This is used for examining objects too small to be visible by ordinary or even ultra-violet light. For example, it has shown that the grains in a developed photographic film have a complicated structure like that of a tangle of string. A beam of electrons is focussed by a combination of electric and magnetic fields which take the place of the lenses of an ordinary microscope. Such a beam behaves in many respects like a beam of light, provided the speeds of the electrons in it are uniform. It forms interference patterns with a suitable grating. And the wave-length of the electrons in the beam makes it impossible to photograph objects much smaller than this length, just as in the case of light. The frequency of vibration associated with an electron is constant, so the wave-length is inversely as the speed of the beam of electrons. Atomic nuclei have similar wave-like properties.

The union, both in matter and light, of these wave-like and particle-like properties, allows the development of an extraordinary degree of complexity even in systems such as a single atom, built up of very few constituents. Thus a hydrogen atom consists of two particles only, yet it can emit a

spectrum in which more frequencies have been measured than the number of notes in a grand piano. The branch of physics which deals with these properties is called quantum mechanics, and might well be called dialectical mechanics. For, at least as at present formulated, it ascribes both to ordinary matter and to radiation properties which common sense regards as irreconcilable. But this contradiction allows of extremely accurate calculation of properties of matter and light which can be measured.

So much for small pieces of matter. Let us pass to phenomena on a larger scale. Consider an organism such as an adult man or insect, which is not growing or diminishing rapidly, from the chemical point of view. Its intake and output of matter balance pretty exactly. But so do those of a steam engine or an internal combustion engine. The organism obeys the same laws as the engine as regards energy, but it differs in some fundamental respects, of which I only mention one. In the machine some parts last more or less unchanged through its " life "; others, such as washers, are occasionally replaced; whilst the lubricating oil is replaced still oftener, and the coal or petrol continually. In an adult animal it has long been known that the soft parts were constantly being renewed, proteins and other organic constituents being built up from the food, and then broken down and excreted. However, one would expect that at least the hard parts, such as bone, would be stable like the hard parts of a machine. Hevesy fed adult rats with sodium phosphate containing some artificially made radioactive phosphorus atoms. He found that after a few days some of these were present in the solid material of the bones. Growth had ceased, but exchange had not. Thus the living substance is a unity of anabolism, or building up, and catabolism, or breaking down of chemical compounds, and this even applies to the bones. The end of this unity of opposites is death. Once an animal is dead, it is possible to preserve it, and the atoms in its tissues mostly stay put for centuries.

If either tendency is carried too far, the unity is destroyed. A man may die of a disease like cancer, where too much material is built up in certain parts, or of a wasting disease such as diabetes, where not enough is built up. But all the manifold developments of life may be regarded as products of this struggle.

The struggle is very obvious within a community of plants and animals, or biocoenosis. All members of it, except plants (generally green) which live by photosynthesis, and saprophytic bacteria and the like, which live on dead organisms or excreta, live by killing or injuring other members. And yet these warring members form a unity which can be upset by altering the numbers of any of them. Thus if wolves eat deer which eat plants, there is a rough equilibrium, though numbers will fluctuate owing to good and bad seasons, epidemics, and so on. If the wolves are killed off the number of deer increases until it is limited by starvation. There are somewhat more deer, but mostly half-starved. Thus in practice some killing by beasts of prey is needed to keep the herbivora in health. Similarly cattle eat grass in a meadow. But they also eat and trample

down larger plants which would choke the grass if it were not grazed. In fact an apparently hostile relation is often to some extent beneficial.

The experience of agricultural development in colonial countries has shown that the killing off of certain members of a community may easily upset the equilibrium by allowing another group of members to increase. There are violent fluctuations of numbers which generally at some point involve a destruction of green plants and impoverishment of the whole community like that which occurs in a capitalist trade slump. Within the unity of the group of species some pairs of species are on the whole antagonistic, some on the whole co-operative, but complete antagonism and complete co-operation are rare. There are obvious analogies with the State, but they must not be pushed too far, if only because the children of capitalists may become efficient workers, and workers may become capitalists, whereas many thousands of years would be needed before the lion would " eat straw like the ox." Still more important are the facts that man is characterized by production, so that human history is determined by economic as well as biological processes, and that he can to some extent consciously plan society, and thus ultimately escape from social forms which are determined by internal struggle.

Now let us rise still higher in the scale of magnitude, to stars. We know more than at the first sight would seem possible about the internal constitution of some stars at least, because the matter in them is not very densely packed, except perhaps at the centre; and though the temperature is very high, that is to say the atoms are moving very fast, their speeds seem to be no greater than we can obtain in a cyclotron. When atomic nuclei collide at these high speeds they sometimes unite, and heat is generated, as in ordinary chemical reactions, but in quantities which are about a million times as large per atom. The rate is sufficient to keep the sun shining at its present rate for many thousand million years. But the development of heat tends to make the stars expand, and the lessened density means fewer collisions, and therefore a slower heat generation. Similarly a decrease of temperature allows the star to contract under its own gravity, so that more collisions occur, and consequently more heat production.

In most stars these two tendencies are in equilibrium over short periods. But in one group of large stars, the Cepheid variables, they are not. These stars pulsate, expanding and contracting with periods of a week or so, and corresponding changes in light intensity. In case it be thought that I am dragging in " conflict " in the interests of Marxist theory, I may be permitted to quote from Gamow's popular *The Birth and Death of the Sun*: " The pulsations come as the result of a conflict between the nuclear and gravitational energy-producing forces in the stellar interior." And in the long run the equilibrium is not stable, in many cases at any rate. Stars undergo two types of explosion. One type produces an ordinary *nova*, a so-called new star of which one flashes up in our galaxy every few years. This is not really a new star, but a vast increase in the light of a previously faint one. The other type, or *super-nova*, is far more brilliant. An explosion of this type occurs in our galaxy about once in a thousand years, and the

exploding star is visible in broad daylight. Enough *super-novæ* have been seen in other galaxies to make it fairly clear that the explosion is much more intense than the ordinary *nova* explosion.

It seems probable that most, if not all stars, explode in one of these ways at least once in their " lives," and then change their structure considerably. It also seems that the explosions are not due to collisions or any other external agency, but to the internal struggle between the expansive and contracting tendencies, which, after millions of years of apparent equilibrium, produces a qualitative leap.

Many more cases might be given, notably the modern chemical theories of tautomerism and resonance energy, especially as developed by Pauling. But these examples should be sufficient to show that recent work is tending to verify Lenin's statement as to " the contradictory, mutually exclusive, opposite tendencies in all phenomena and processes of nature," and the view that the struggle between these tendencies is the cause of development.

III. QUANTITY AND QUALITY

THE transformation of quantity into quality, and conversely, was regarded by Marx and Engels as a fundamental dialectical process. Marx states one aspect of it very clearly, when writing of the relation between small savings and capital. " Here," we read, " as in natural science, is verified the correctness of the law discovered by Hegel in his *Logic* that merely quantitative changes beyond a certain point pass into qualitative differences." Engels used the phrase to describe four slightly different facts. The " transformation " could either be a process actually undergone by a material system, as " when the taut rope parts under the pull," or a change found as we pass, in thought or perception, along a series of things which can exist at the same time, and which differ quantitatively, such as the chemical elements or the paraffin hydrocarbons, which are built up out of different numbers of the same fundamental units. He also applied it both to gradual changes such as the melting of waxes, which have no definite melting point, and very sharp ones such as the melting of ice. Doubtless a sudden transformation of an object or system shows the principle in its sharpest form.

The mechanics of Galileo and Newton were based on the ideas of continuous space, time and motion; and the contradictions inherent in the latter, pointed out by Zeno and others, were ignored. The classical mechanics could explain some sudden changes. For example, it was clear why a stick suddenly fell when it was gradually pushed off a table, and it was hoped that all sudden changes would be explicable in this sort of way. However, classical mechanics have been unable to explain such simple phenomena as the breaking of a bar, or the boiling of a kettle. By explanation I do not, of course, mean merely verbal explanation, but numerical explanation, which would enable us to calculate, say, the boiling point of water from simple properties of hydrogen and oxygen atoms.

During the present century it has become clear that only some of the laws

of classical mechanics apply to atoms. They apply to large bodies consisting of many billion atoms simply because they are statistical consequences of the pooled motion of many atoms. This fact was predicted two thousand years ago in Epicurus' and Lucretius' doctrine of *clinamen*, according to which atoms showed a less regular behaviour than larger bodies. They do this because, under some circumstances at least, motion is only transferred to or from an atom in definite quantities, whereas according to classical mechanics it could be transferred continuously. In particular, angular momentum, or spin, is only transferred in definite units, or quanta, which are the same for all atomic events. An atom can exist in a number of different states, with different spins. And these states are qualitatively different. An atom with more than the minimum spin is liable to give out a flash of light. It is generally more active chemically than one with less spin, and so on. In fact, the transformation, and what is more, the abrupt transformation, of quantity into quality, is, at least at the level to which modern physicists have penetrated, a fundamental property of matter. Many continuous changes depend on this sharp type of change, and not the other way round.

The action of the nervous system, both in sensation and in voluntary or reflex action, is based on the same principle. Every cell in the nervous or muscular system, and very probably every gland cell, too, has a threshold of excitability, that is to say a minimum stimulus which is needed before it can do anything.

Further, the activity of a cell is seldom graded. A muscle fibre contracts with all its available energy, or not at all. A nerve fibre either does nothing, or transmits a unit impulse which is no stronger, and travels no faster, if the stimulus which starts it is greatly increased. Graded activity of an organ is possible by altering the number of units, for example muscle fibres, contracting at any moment, or the frequency with which each contracts. In the case of a muscle fibre a sufficiently rapid series of stimuli, each of which would cause a twitch, lead to a steady contraction.

On these principles we are beginning to understand some of the processes involved in simple sensation. A number of sensory nerves end in knobs which are sensitive to pressure. A very light pressure on such a knob may cause only a single impulse to travel along the fibre towards the brain. A moderate pressure will cause a series of impulses, at first frequent, then slowing down. A greater pressure is translated into a more rapid series, also slowing down in the end. The same seems to be true for more complicated sense organs. Our whole knowledge of the external world, and our whole action on it, depend on the numbers of nervous impulses going in and out through a few million nerve fibres. These impulses are all of the same nature, chemical changes with accompanying electrical potentials of a few millivolts. They do not seem to differ qualitatively according to whether they are destined to cause sensations of sound or warmth, pain or pleasure, or even to bring about secretion or motion. The whole qualitative richness of the external world, or of a philosopher's or poet's mind, is transformed into quantity at this level.

The change back to quality on the way inwards is only partly understood. But it depends on thresholds which vary qualitatively as well as quantitatively. Each sensory nerve fibre connects with a number of cells in the spinal cord or brain, from which more fibres arise. A large number of impulses arriving at once along fibres from the same part, as when a blow is given, will excite the relatively sluggish cells concerned in a reflex action such as withdrawing a limb. Even strong stimulation of a single end organ in the skin can probably never start a reflex, and rarely reaches consciousness. Repeated impulses along one fibre will stimulate nerve cells which do not respond to single stimuli. Simultaneous impulses from a number will stimulate cells which do not respond to repeated stimuli from one fibre, and so on. Thus as we travel up the central nervous system towards the cerebral cortex the nervous activity comes more and more to represent patterns of stimuli in the external world. And finally in the cerebral cortex the relevant patterns correspond to material objects, words, and so on, so that we are directly aware of these, and not of the series of points of pressure or colour, or isolated elements of sound, into which some philosophers have tried to analyze our perceptions.

The transformation of quantity into quality on the way out, involved in skilled muscular movement, will perhaps be easier to investigate, but has been less studied. This is probably because physiologists have so far been under the influence of philosophies which regarded sensation as more important than action—as indeed it is for a leisured class. When we know in detail how the impulses coming down the arm nerves are translated into skilled hand work we shall probably obtain many clues to the converse transformation of quantity into quality in the brain.

The transformation of quantity into quality is very clearly shown in the course of evolution. Suppose the linear dimensions of an animal to be increased ten times, but its shape unchanged, then its bulk is increased a thousand times, but its surface only one hundred times. Thus if its chemical changes go on at the same rate, each area of gut must pass in ten times as much food per day, each area of lung or gill ten times as much oxygen, and so on. So the animal will only be able to live an active life if the area of the gut is increased by coiling it, throwing its surface into numerous projections, and so on. Similarly the gills and lungs must become more complex, the circulation must become more efficient, and so on. In fact, it is probably truer to say that the most advanced animals are complicated because they are large, than that they are large because they are complicated.

Many more examples might be given, but I will end on a personal note. It is often said that Marxism is somewhat of a pose in scientists who adopt it, and that it does not influence their research. During the nineteenth century it was found that many gases could be liquefied by cold, and Engels, among others, predicted that a quantitative change of temperature would lead to a sharp qualitative change of state in all of them. This has now been found to be the case. However scientists, whether or not they are materialists, were almost all unduly mechanistic. Qualities such as taste or smell were thought less real than quantitatively

measurable characters such as density. Now a gas such as hydrogen sulphide with a strong smell, or carbon dioxide with a strong taste, is inodorous and tasteless until it reaches a certain concentration, which is the threshold for the human sense organs. The threshold is best measured as partial pressure. Hydrogen sulphide is first smelt at a pressure of about a millionth of an atmosphere, carbon dioxide first tasted at a pressure of about a fifth. It is obvious that a gas such as oxygen, which has no smell or taste when breathed pure at a pressure of one atmosphere, may yet be perceptible at higher pressures.

It was not, however, obvious to a number of scientists who had been at a pressure of six atmospheres, corresponding to 170 feet of sea water; because they recognized the transformation of quantity into quality in special cases, but not as a general principle, or believed in the " lesser reality," to use a phrase of Lenin's, of smell and taste as compared with shape and rigidity. So I was the first person to taste oxygen. At six atmospheres' pressure it tastes like rather flat ginger beer. At higher pressures it may perhaps develop a smell. This simple example shows that the law of the transformation of quantity into quality is not merely a convenient summary of a number of previously discovered facts (though both the quantum theory and the thresholds of nerve cells were discovered after Engels' death), but a living and fruitful guide to actual scientific discovery.

IV. NEGATION OF THE NEGATION

THE contradictions embodied in a system commonly lead to a struggle, which results in development. Where we can follow the detail of this struggle, we find that the formula of the negation of the negation often expresses the final phase, which leads to the sudden " emergence " of novelty, with remarkable accuracy, as in Marx's description of the transition to socialism, " The expropriators are expropriated."

We do not know enough of the detail of how unstable atoms or molecules undergo sudden change to say how, if at all, this principle applies. But it certainly applies to the familiar irreversible physical changes such as the breaking of a stick or metal bar which is overbent, or a rope or rubber band which is overstretched. Under no external strains, or slight strains, the molecules of a solid are commonly arranged in a system of minimum energy (like a stone lying at the bottom of a bowl instead of being perched in a less stable position). They may be arranged in crystals, as in cast iron, or fibres as in wood. Now a strain such as bending or pulling upsets this arrangement. The stable configuration of molecules is negated. In its early stages this process is reversible. The solid regains its former shape if the force on it is removed. But at a certain point the negation is abruptly negated. The solid breaks, and each part returns to a stable configuration of molecules. There may of course be intermediate stages of permanent set. This is of course a crude example. In other cases the negation of the molecular

arrangement leads, after a more or less chaotic period, to a new one. Thus when ice near its melting point is compressed, it first melts, that is to say the molecules lose their orderly arrangement, but at about 6,000 atmospheres it passes into another solid form, ice-VI, in which the molecules are more densely packed than an ice-I, the well-known form.[1]

A beautiful example of a negated negation is found in the modern geological theory of the formation of certain mountain ranges, such as the Alps. These occur in regions of folding where the earth's crust, by cooling or continental movement, is under lateral pressure. The first effect of this pressure is to cause a downward folding, such as occurs, for example, off many of the coasts of the Pacific, where there are deep oceanic troughs. These are filled with sediments which form rock. As the folding progresses these sediments are brought up again above sea level. Being lighter than the granite of which the continents are largely composed, they can form comparatively stable mountain ranges of considerable height, whereas a range consisting of heavier rocks would gradually sink when the mountain-building forces no longer acted. Thus the down-fold, or geosynclinal, is transformed into its opposite, a mountain range.

But the negation of the negation is most strikingly shown in the field of biology. The most primitive organisms merely grow and divide. If they break down the large molecules of their bodies into smaller molecules which are excreted, this is a negation of their life process. But in the higher animals the breakdown of relatively large molecules, such as glycogen and adenosinetriphosphoric acid, is the immediate source of the energy of muscular movement, which enables them to get food which is quite unavailable to the simplest organisms. The negation of growth thus negates itself.

The evolutionary process depends on the struggle between variation and selection. As Engels pointed out, either may be taken as positive. However, the following treatment is perhaps the most consonant with modern biological ideas. Normally like produces like, or nearly so, whether in growth, as when one potato or geranium produces many vegetatively, or in sexual reproduction. More accurately, like responds alike to a similar environment. Some variation within the progeny of a single organism or pair is merely due to the different responses of fundamentally similar organisms to different nurtures. Some, including sex differences in most species, is due to hybridity, that is to say to the fact that the original organism considered, or one of them, was formed by the union of germ-cells whose nuclei were unlike. But some variation is due to mutation, a radical change which may produce entirely novel types, and which leads to hybridity in later generations, and thus furnishes the raw material for all kinds of heritable variations. Mutation is in fact the negation of heredity. The novel

[1] I have been criticized for writing dogmatically about " hypothetical " arrangements of molecules. In a full-scale book I might have summarized the evidence on which my statements are based. Here I can only remark that it is much stronger than was the evidence for the Copernican theory in Newton's time. And as I have repeatedly staked my life on the substantial correctness of molecular theory, I can claim that my thinking on it is " this-sided."

types produced by mutation very rarely prove fitter than the original type. So natural selection generally eliminates them, though occasionally one may spread through a species and transform it. The negation is usually negated. But this does not give us a uniform species, for many disadvantageous mutants are eliminated quite slowly. On the contrary, as Tsetverikov first showed, and Dubinin and others, including Gordon, Philip, Spurway and Street in my own laboratory, have proved in greater detail, it leads to a state of affairs where the species is permeated with small variations, more or less harmful one at a time, but sometimes beneficial in suitable combinations, or potentially useful if external conditions change. Fisher believes that the struggle between mutation and selection causes slow changes in a species which are not due to environmental pressure, and thus gives an internal cause for evolution such as has been attributed to vital urges and the like. It certainly makes a species more variable and plastic than it would otherwise be.

Evolution proceeds by the same method in many details. Every major change of environment negates the former normal conditions of the organism. Thus when our fish ancestors came out of water they could not move quickly on land. They breathed with difficulty, saw badly, were subject to rapid temperature changes such as do not occur in water, and so on. It took many million years to negate these negations. They were negated by the development of such organs as legs and lungs, by large changes in the eyes, and finally by mechanisms for regulating the temperature. These when they were perfected, enabled the mammals and birds to colonize even the arctic, and rendered many other developments possible. Man has recently developed a large brain which, among other things, has cramped his teeth and bent his nasal passages. The teeth and nose are among the weakest and most readily infected parts of our bodies. Natural selection is likely to negate this weakness in our remote descendants.

Finally the negation of negation is extremely typical of the development of scientific theory and practice. Here at least Hegel was not standing on his head. His account of the dialectic needs far less modification in connection with human history than with nature. The dialectical development of mathematics was described by Engels,[1] to whom readers are referred. At the end of the nineteenth century the atomic theory in chemistry was generally accepted, though Ostwald and a few other chemists stood out. But the number of atoms in a gram was uncertain within a factor of a hundred or more. Then Thomson showed that electrons could be detached from atoms in a gas, and Rutherford that atoms broke up. This negated the atom as an " eternal brick," but made it possible to count atoms with great accuracy, since individual electrons or atomic explosions produce effects which are visible with a microscope.

We have seen how widely Marxist principles are applicable to modern science. Some scientific workers admit this, but add that Marx and Engels only formulated principles which good scientists follow instinctively. Even if this were the whole truth, their formulation would have been a very great

[1] *Dialectics of Nature.*

step forward. But actually an individual scientist will often turn out to be quite dialectical in his treatment of some particular problem, say resonance energy or reflex action, but crassly mechanistic or idealistic when dealing with other questions, including his own social and economic position. For this reason every scientific worker will be aided in his work by a study of such classics as *Feuerbach*, *Anti-Dühring*, *Dialectics of Nature*, *Materialism and Empirio-criticism*, and chapter 4 of the *History of the C.P.S.U.* (B). He must remember that they must be studied not as eternal truths, but in their historical setting; not as dogmas, but as guides to action. If he does so he will not merely improve the quality of his research and teaching; he will find himself no longer a mere individual passively involved in the torrent of contemporary history, but actively engaged in changing society and shaping the world's future.

V. MATERIALISM AND ITS OPPONENTS

WE shall not be able to counter the arguments which philosophers and scientific workers bring against materialism unless we understand not only their social origin but the considerable measure of truth behind them. Lenin[1] wrote that " Philosophical idealism is only nonsense from the standpoint of crude, simple, metaphysical materialism. On the other hand from the standpoint of dialectical materialism, philosophical idealism is a one-sided, exaggerated development of one of the features of knowledge into an absolute, divorced from matter. . . ."

In each generation the undialectical materialists try to explain everything in terms of matter and motion described in terms which may be adequate for school physics, but are quite inadequate even for the very abstract view of the world needed by the laboratory physicist. No wonder they are of little use to the biologist, and still less to the psychologist. The syllogism of the idealistic biologist runs, " Matter has the properties which were taught to me at school. These properties will not explain life, let alone mind. Therefore matter does not exist, or at any rate there is a spiritual world independent of matter." Because the first and third clauses are untrue, we must not forget that the second is true. Many of the idealistic writings of contemporary scientists (though not all) are of real value as criticisms of mechanistic materialism.

In the ancient Greek world the class which was rising when philosophers began to study the world was a class of merchants. They required arithmetic for their calling, and it was natural that Pythagoras, who, according to Aristoxenus, " was the first to develop mathematics beyond the necessities of trade," should identify reality with number. The rising bourgeoisie of the seventeenth century were concerned with navigation, ballistics, and mining, especially the operations of lifting solids and pumping water. For Newton and his followers, including the philosophical school of Locke, matter had extension and mass, but its other properties, such as colour,

[1] *On Dialectics.*

taste and smell were "secondary" and illusory. The Newtonian or mechanistic conception of nature only broke down within the sphere of physics after over two centuries, and still dominates scientific thinking because a post-Newtonian theoretical physics, including relativity and quantum mechanics, is only now being framed.

We can get some idea of what this physics will be like by studying the mathematical framework, which is the scaffolding, so to say, for the new building. The old Greek merchants had been largely concerned with the simplest possible relations between material objects which are symbolized by the word "and." Number, weight, and bulk are additive. Two and three are five, two ships and three ships are five ships, two pounds and three pounds are five pounds. Newtonian physics involved more complex relations. Thus the gravitational force between two bodies is proportional to the product of their masses. The gravitational force between a two-pound weight and a three-pound weight is not five but six times the force between two one-pound weights at the same distance. A particle was supposed to be fully described by three numbers representing its position in space, three more representing its velocities in three perpendicular directions, and others representing its mass, electric charge, and so on. But for modern quantum mechanics as developed, for example, by Dirac, a particle is represented by an operator. An operator is a mathematical activity, a verb, as it were, in the mathematical language, which converts one function into another. Thus the operator $\frac{d}{dx}$ converts x^2 into $\frac{1}{2}x$, sin x into cos x, and so on. The operator E converts x^2 into $(x+1)^2$, sin x into $\sin(x+1)$, and so on. The action of the much more complicated operator representing a particle on a function representing waves or vibrations gives the most accurate numerical predictions so far available as to how the particle will behave. The substitution for a self-existent particle of something which can only be described in terms of its actions on other things is clearly a step in the direction of dialectrical materialism.

We cannot tell in detail what the new world picture will be like. As Lenin[1] put it: "It is, of course, absurd to say that materialism ever . . . professed a 'mechanical' picture of the world, and not an electro-magnetic or some other, immeasurably more complex, picture of the world as matter in motion."

But we can be sure that on the one hand it will fit the mathematical scheme which is now being developed, as the picture of the world in terms of indestructible particles with no properties but position, size, attraction and repulsion, fitted Newton's and Laplace's mathematical scheme. And we can be nearly sure that in doing so it will take account of qualities such as colour, sound and smell, which are "secondary" and unreal for mechanistic materialism. It is noteworthy that just as Planck and Einstein showed that light behaved, not only as if it were composed of waves, but of particles, the Soviet physicist Frenkel has applied the same treatment to sound, some of whose properties are most readily calculated if it is regarded

[1] *Materialism and Empirio-criticism.*

as consisting of particles which he calls phonons. Thus the new physics will not merely be more accurate quantitatively than the old. It will give a more concrete account of the world, including many of the qualities which, according to dialectical materialism, but not to idealism or mechanical materialism, really exist in the real world.

Eddington has succeeded in making some deductions concerning the general nature of physical systems, for example the ratio of the masses of a proton and an electron, from the fact that they are capable of being experienced, and draws the idealistic conclusion that their whole being consists in being experienced. Not all his colleagues agree with his deductions; but even if they are correct, the capacity of matter for acting on our sense organs, and thus being experienced, is only one of its physical properties, and Eddington might as well have started off from one of the others. If men were immaterial souls somehow watching the external world through the sense organs, we should have no guarantee that matter was at all like our perceptions of it. But actually we have acquaintance with matter in two different ways besides direct perception through the sense organs. As Marx never tired of pointing out, we act on it as well as perceiving it. In so far as our actions are successful, this guarantees that our perceptions are not illusory, at least in some respects.

We have also a third source of information. If our brains think and feel, then every fact about human consciousness is a fact about matter, namely the matter of our brains. True, we do not perceive our brains directly, but we learn facts about them which we could never learn by direct perception. We learn that some material systems can feel, think, and will. Now this fact has been the basis of two distorted views which are sometimes held by the same person. One is idealism, the theory that feeling, thought and will are the reality of which matter is the appearance. If our sensation and ideas are images of matter, it follows that matter is like them. If your photograph is like you, you are like your photograph. Similarly, some relations between material objects or events are like thought, force is like will.

The question is, which is the model and which the copy? Modern followers of Mach, such as Carnap, say that the question is meaningless; the world can be "logically constructed," taking either matter or mind as primary. If Carnap were an eternal being, the only one of his kind, he would be right. But Marx and Engels first saw that the question can only be answered on social and historical grounds. If you are in doubt which of two things is a model and which a copy, find out which was there first. Matter was there before men or any higher animals, probably before life at all. Hence matter is the model, and mental events the copy. And hence the extreme philosophical importance of evolution, of which, by the way, an account could only be given when the development of mines and canals had revealed the fossil record.

The other distortion, mysticism, which is associated with some forms of idealism, is the theory that important information about the universe can be gained without any sense impressions, after withdrawing the mind from the external world by ritual, meditation, or chemical substances such as

nitrous oxide. This is opposed to the view that " there is nothing in the intellect which was not first in a sensation." Historically mystics have generally begun by intuitions of the truth of some religion. But the greater mystics have often stated that the God with whom they claimed unity was not a person. In fact many of them were more than half-way to atheism, and some Buddhist mystics have been complete atheists. Mystical experience is a fact, but it is primarily a fact about the brain. It may give some information about the universe, but this information will be even further from the truth than that of our senses. Our senses tell us that the sun goes up and down every day, that mustard is hot, that a stick thrust into water is bent, and so on. Mystical experience is still more fallacious. The theories based on it are sterile flowers, as Lenin said. But they are rooted in reality. The reality behind mystical experience is perhaps the perception of a unity which may have been a commonplace for a member of a primitive tribe, and will perhaps be equally obvious to a member of the communist world society of the future, but which even members of the socialist society of the U.S.S.R. can only grasp in part. In a class society this reality can only be expressed in a highly mythological form.

Thus a radical, dialectical materialist need not, and indeed must not, neglect any parts of human experience. On the other hand, until the physiology of the brain has been developed a great deal further, the materialistic account of consciousness must be extremely sketchy, and Marxism will be mainly useful in describing its social relations rather than its physical basis.

It is important to refute the widely held view that idealism makes for good conduct. The moral implications of idealism were, I believe, stated once for all in *A little boy lost*, by William Blake:

> " Nought loves another as itself,
> Nor venerates another so,
> Nor is it possible to thought
> A greater than itself to know."

Idealists all agree with the last two lines. How nearly they agree with the first two is shown by their attempts to justify virtue by explaining that I am " really " identical with my neighbour, generally because both of us are identical with God or the Absolute. Idealists can, of course, be virtuous; but their idealism often helps them to the comfortable belief that other people's sufferings are not real; and they cannot reach the peak of virtue of a materialist who deliberately gives up his or her life, without hope of a future life, for a great cause, as hundreds of thousands of materialists are doing today in the Soviet Union.

Above all idealism is dangerous in the political field, where it leads to the liberal belief that good intentions will make an out-of-date economic and political system work, and the anarchist belief that they are enough without any political system at all. To combat idealism we must understand its strong points as well as its weak ones, and be able to explain to idealists that dialectical materialism embodies the really valuable and fruitful elements in their philosophy.

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"Labour Monthly" Discussion Groups

ABOUT two years ago groups of *Labour Monthly* readers in various parts of the country commenced to organise monthly discussions amongst themselves on the questions and policies treated in the current issue. Their object was an educational one. For a variety of reasons political discussion of a serious, organised kind did not enter into their lives. Some of them were members of no political party or trade union, were just solitary readers; they eagerly grasped at an opportunity to exchange ideas, to learn from others, and through discussion to acquire a firmer grasp of political realities. Others were indeed members of one organisation or another, but felt the need of serious political discussion with people of a basically similar outlook, in order to equip themselves to play a more useful role within their particular organisations.

Then, people who were not yet readers of *Labour Monthly* but were becoming interested in Left Wing politics started attending these small discussion groups and helped by the more experienced people they were meeting and listening to, commenced a process of political education which changed their outlook and gradually brought them into useful forms of activity. The old feeling of futility and frustration, of perplexity and doubt, was ended for all of these.

The value of these Discussion Groups in developing the political level of the Labour Movement was recognised, and a special Discussion Groups Department was established, whose function is to give guidance and political assistance to the Discussion Groups and to encourage their formation wherever possible. All those interested, either in forming a Discussion Group, or in attending one already in existence, should write to:

DISCUSSION GROUPS ORGANISER,
Labour Monthly,
134 Ballards Lane,
London, N.3,

who will be delighted to send them the fullest possible information and suggestions.